RESEARCH

European Pharmacy Students' Experience With Virtual Patient Technology

Afonso Miguel Cavaco, PhD, and Filipe Madeira, PharmD

Faculty of Pharmacy, University of Lisbon, Portugal

Submitted October 7, 2011; accepted February 13, 2012; published August 10, 2012.

Objective. To describe how virtual patients are being used to simulate real-life clinical scenarios in undergraduate pharmacy education in Europe.

Methods. One hundred ninety-four participants at the 2011 Congress of the European Pharmaceutical Students Association (EPSA) completed an exploratory cross-sectional survey instrument.

Results. Of the 46 universities and 23 countries represented at the EPSA Congress, only 12 students from 6 universities in 6 different countries reported having experience with virtual patient technology. The students were satisfied with the virtual patient technology and considered it more useful as a teaching and learning tool than an assessment tool. Respondents who had not used virtual patient technology expressed support regarding its potential benefits in pharmacy education. French and Dutch students were significantly less interested in virtual patient technology than were their counterparts from other European countries.

Conclusion. The limited use of virtual patients in pharmacy education in Europe suggests the need for initiatives to increase the use of virtual patient technology and the benefits of computer-assisted learning in pharmacy education.

Keywords: virtual patient, simulation, pharmacy education, Europe, survey

INTRODUCTION

Healthcare education, including pharmacy practice, has benefited from simulation-based learning since the early 1970s.[1,2] Several types of simulation have been used in pharmacy education in the United States, including simulated and/or standardized patients, computer-based learning simulations, high-fidelity human simulators, and virtual-reality patients.[2] Multimedia-based healthcare education, including the use of virtual patients, is considered to be educationally effective and has been described favorably when compared with traditional instruction.[3]

There are varying proposals for how to define virtual patients. For instance, in proposing a virtual patient typology, Huwendiek and colleagues described it as "an interactive computer simulation of real-life clinical scenarios for the purpose of healthcare and medical training, education, and assessment."[4] Apart from a number of medical specialties comprising, among others, training in life-saving events,[5] virtual patients have also been used in other health professions, ranging from nursing[6] and occupational therapy[7] to pharmacy practice.[8,9] Pharmacists have participated in initiatives to test virtual patient-based education within multi-professional groups,[10] as well as in initiatives to develop interprofessional integration among health professions students.[11]

Among other purposes, virtual patient technology was designed to promote students' clinical reasoning[12] and the development of communication skills.[13] Users' opinions of this educational resource, including medical students' acceptance of virtual patient design principles and of virtual patient-based learning and assessment tools, indicate that virtual patient technology benefits both clinical reasoning and communication skills.[14-16]

In addition to virtual laboratories for training students in the basic sciences,[17] multimedia simulation[18,19] and virtual patient technology[20] have been successfully implemented in pharmacy education. While there have been European virtual patient technology initiatives since the early 2000s,[21,22] in particular the development of shared electronic patients (eViPs) across European countries,[23] use among European colleges and schools of pharmacy is not widespread and European users' opinions of this computer-assisted educational resource are not well known.

The objective of this study was to explore the perceptions and attitudes of European undergraduate pharmacy students regarding the use or potential use

Corresponding Author: Afonso Miguel Cavaco, PhD, Faculty of Pharmacy, University of Lisbon, Av. Prof. Gama Pinto, Lisbon, Portugal 1649-003. Tel: +351217946456. E-mail: acavaco@ff.ul.pt

of virtual patient technology during their pharmacy education, and to use these findings as a starting point for a more comprehensive survey of pharmacy education programs and students in those programs.

METHODS

The research followed a descriptive, observational cross-sectional design that used a printed self-administered survey instrument to gather data. The aim was not to obtain a statistical representation of users' of virtual patient technology in the European pharmacy student population, but to create a first portray of how this technology is being used.

Following ethical approval by the University of Lisbon's Faculty of Pharmacy's ethics committee, European Pharmaceutical Students' Association's (EPSA's) executive board gave its informed consent to conduct the survey. EPSA encompasses 28 European pharmacy student associations as well as individual members. The study was introduced and survey instrument administered during a plenary session of EPSA's 34th Annual Congress in April 2011, in Lisbon. After being informed about the study's purpose and implications, participants voluntarily completed the questionnaire. The data from this convenience sample were collected anonymously and handled confidentially. In a culturally diverse group that encompassed different countries and universities, researchers were aware that differences might exist in study participants' concepts of virtual reality and virtual patient technology. Thus, to avoid any associated bias, the survey instrument followed the virtual patient technology model definition proposed by Keele University,[9] which defines virtual patient technology as "an interactive learning system that creates a computer-simulated environment of patient real-life scenarios." This definition was included in the survey preamble. In order to contextualize the scope of the survey instrument further, the preamble contained the following additional information: "Interaction with virtual patients occurs in a simulated reality created by computer software, with animated images and sounds, where the student talks and listens to the patient, as well as dealing with patient's emotions."

Following the preamble, there were 3 main sections to the questionnaire. The first was directed at participants who had experience in computer-based interaction with virtual patients. The second was designed for respondents who had not yet used virtual patient technology but considered themselves potential virtual patient technology users because they had experience using other forms of computer-assisted education, such as Web-based learning, digital network collaboration, or other audio/video-based media. Apart from factual data-gathering, these 2 sections also comprised a set of sentences, related to respondents' virtual patient technology use or potential use (7 and 4 items, respectively), and the perceived impact these had or would have in the learning process. These items were rated on a 5-point Likert scale, ranging from "strongly disagree" to "strongly agree." Survey items were developed based on findings from a literature review[25,26] and were intended to assess participants' attitudes, without any psychometric aims. The third section solicited participants' demographics, including their computer proficiency, which students rated on a 7-point Likert scale. Descriptive statistics as well as some inferential analyses were performed, with a significance level set at $p<0.05$ for all tests.

RESULTS

There were 304 registered participants in the EPSA congress representing 72 universities in 26 different European countries. The majority (68.3%) were female; fourth- and fifth-year students were the most widely represented, comprising 50.8% of all registered participants (including internship students).

One hundred ninety-four respondents from 46 different universities completed a survey instrument, resulting in a 63.8% participation rate. Responses were deemed valid if respondents either claimed to have or not have experience with virtual patient technology in their pharmacy education. There were missing responses from congress participants representing the Czech Republic, Hungary, and Serbia. Approximately 70% of the student respondents were female and 90.0% were between 19 and 23 years of age. Although 26 different nationalities were represented, all but 1 student (an Iraqi) were European. There were no significant differences in age, gender, and country and university of origin between the respondents and all registered congress participants ($p>0.05$). Table 1 presents students' origin by country and university.

Of 194 European pharmacy students, only 12 (6.2%) had experience with virtual patient technology (designated in Table 1 with an asterisk), while 182 respondents (93.8%) reported no experience with this technology. In the virtual patient users' group, 3 respondents had experienced patient simulation that used 3-dimensional images and sound, whereas 9 described using other forms of electronic patient simulation, such as animated 2-dimensional images, with or without sound. Eight students had used virtual patient technology that involved selecting from multiple-choice items and text boxes or hearing audible responses from the virtual patient. For 3 respondents who had used virtual-reality systems, the experience included listening to and speaking with virtual

Table 1. Countries (n=23) and Universities (n=46) Represented by Respondents to a Survey on Use of Virtual Patient Technology in Pharmacy Education

Country	University	Survey Participants, No. (%)
Bulgaria	Medical University of Sofia, Bulgaria	2 (1.1)
Croatia	University of Pharmacy and Biochemistry, Croatia	5 (2.7)
Denmark	University of Copenhagen,* Denmark	5 (2.7)
Finland	University of Helsinki, Finland	4 (2.1)
	University of Eastern Finland, Finland	1 (0.5)
France	University of Rennes, France	1 (0.5)
	University of Grenoble, France	1 (0.5)
	University of Reims, France	1 (0.5)
Germany	Ruprecht-Karls University of Heidelberg, Germany	1 (0.5)
	University of Freiburg, Germany	2 (1.1)
	University of Bonn, Germany	1 (0.5)
Greece	University of Patras, Greece	4 (2.1)
Italy	University of Genoa, Italy	2 (1.1)
	University of Catania, Italy	1 (0.5)
Latvia	University of Latvia, Latvia	3 (1.6)
Lithuania	Lithuanian University of Health Sciences, Lithuania	3 (1.6)
Macedonia	Ss. Cyril and Methodius University of Skopje, Macedonia	3 (1.6)
Malta	University of Malta, Malta	1 (0.5)
Norway	University of Bergen,* Norway	6 (3.2)
	University of Oslo, Norway	3 (1.5)
	University of Tromsø, Norway	5 (2.7)
Poland	Medical University of Warsaw, Poland	5 (2.7)
Portugal	University of Coimbra,* Portugal	9 (4.8)
	University of Lisbon, Portugal	21 (11.2)
	University of Porto, Portugal	7 (3.7)
	Institute of Health Sciences Egas Moniz, Portugal	1 (0.5)
Romania	Carol Davila University of Medicine and Pharmacy, Romania	17 (9.1)
	Iuliu Hatieganu University of Medicine and Pharmacy, Romania	1 (0.5)
	Victor Babes University of Medicine and Pharmacy, Romania	1 (0.5)
	University of Cluj-Napoca,* Romania	1 (0.5)
Slovenia	University of Ljubljana, Slovenia	17 (9.1)
Spain	University of Santiago de Compostela, Spain	2 (1.1)
	University of Alcalá de Henares, Spain	1 (0.5)
Sweden	Uppsala University, Sweden	9 (4.8)
	University of Gothenburg,* Sweden	2 (1.1)
Switzerland	ETH Zurich, Switzerland	2 (1.1)
	University of Basel, Switzerland	3 (1.6)
The Netherlands	University of Utrecht, The Netherlands	3 (1.6)
	University of Groningen, The Netherlands	1 (0.5)
Turkey	Ege University, Turkey	1 (0.5)
	Hacettepe University, Turkey	10 (5.3)
	Anadolu University, Turkey	4 (2.1)
	Marmara University, Turkey	6 (3.2)
	Istanbul University, Turkey	5 (2.7)
United Kingdom	University of Portsmouth, United Kingdom	1 (0.5)
	University of Aston,* United Kingdom	2 (1.1)
Missing origin		7 (–)
Total		194 (100.0)

patients that had speech and voice recognition capabilities. Six students reported having experienced virtual patients within the context of a single subject or course, such as pharmacy practice or pharmacotherapy. The course(s) involving virtual patients were offered during 1 semester between years 2 and 4 of the students' pharmacy education program. The other 6 students had used virtual patient technology more extensively, including but not limited to independent/individual study, work groups, case studies, as a lecture aid, in practical teaching, and as a supplementary resource. It was not possible to confirm length and depth of use (ie, beyond a semester or in multiple subjects).

Of the teaching/learning methods that are associated with use of virtual patient technology, the most common (n=9) occurred through a combination of work group and case study. Virtual patients were used mostly during lessons (n=8) and in lesson preparation (n=3), and to a lesser extent in lesson follow-up, examinations, or other forms of summative assessment (n=1). Only 2 students were aware of the point in time when virtual patient technology was implemented as mandatory to complete the pharmacy degree (before 2005). In most cases (n=5), virtual patient software was developed by their university or shared by another academic institution, but commercial solutions were also purchased (n=7).

When asked about their computer proficiency, the mean response of the subgroup of virtual patient technology users was 6.2 ± 0.9 on a 7-point scale on which 7 = excellent. The perceptions about virtual patient technology held by students who claimed to have experience using and mastery of Internet technology are displayed in Table 2. In this small, non-representative sample, the mean values of all items were on the positive side of the Likert scale; however, some respondents did express negative opinions (disagreed or strongly disagreed) about the following items: virtual patient technology gave me an insightful learning experience, (8.3%); learning with virtual patients was important to performing well on the final examination (16.7%); easy access to virtual patients at my convenience (25.0%); and a combination of virtual patients and teaching events enhanced clinical reasoning skills (9.1%). Bivariate nonparametric Spearman correlations were computed, showing a strong positive correlation between "virtual patient content and corresponding teaching events complemented each other well" and "virtual patients gave me an insightful learning experience, which I wouldn't have had from corresponding teaching events alone." (rho=0.74; p=0.006). A negative correlation was found between "virtual patient content and corresponding teaching events complemented each other well" and "combination of virtual patient technology and corresponding teaching events made me feel better prepared to care for a real life patient" (rho=-0.67; p=0.025).

Of the 182 respondents who described themselves as not having experienced virtual patient technology, 72.9% had used e-learning resources in their curriculum, 52 (29.1%) of whom indicated they had used blended-learning resources. There was no significant difference between the use of synchronous (52.9%) and asynchronous (47.1%) systems. When questioned about the need for virtual patient technology in their curriculum, 83.5% agreed they should be used. Of these, 68.1% asserted that the greatest need for virtual patient technology is in teaching and to a lesser extent in assessment (15.4%) but that virtual patients are especially useful in practical individual learning (73.8%). Students' self-assessed their computer proficiency as 5.0 ± 1.3 on a 7-point scale. This value was lower than the mean for the students who reported virtual patient technology use (p=0.003). Table 3 presents the perceptions of non-virtual patient technology

Table 2. Perceptions Regarding Educational Use of Virtual Patients Among European Pharmacy Students With Virtual Patient Experience (N=12)

Survey Item	Mean (SD)[a]
VP-related content and correspondent teaching events complemented each other well	4.3 (0.7)
VPs gave me an insightful learning experience, which I wouldn't have had from corresponding teaching events alone.	3.9 (0.9)
Learning with VPs is important in order to do well in the final examination for the course	3.7 (0.9)
Easy access to VPs at my convenience	3.4 (1.3)
Combination of VPs and corresponding teaching events enhanced my clinical reasoning skills.[b]	3.9 (1.0)
Combination of VPs and corresponding teaching events made me feel better prepared to care for a real life patient.[b]	4.3 (0.8)
Overall, the combination of VPs and corresponding teaching events was a worthwhile learning experience.[b]	4.6 (0.7)

Abbreviations: VP=virtual patient.

[a] 5-point Likert scale on which1=strongly disagree and 5=strongly agree.

[b] Not all respondents answered this item.

Table 3. Perceptions Regarding Educational Use of Virtual Patient Technology Among European Pharmacy Students With No Virtual Patient Experience (N=182)

Survey Item	Respondents, No. (%)[a]	Mean (SD)[b]
I believe computers are indispensable tools for my learning process.	173 (95.1)	4.1 (1.2)
I believe e-learning platforms are helpful to improve my learning skills.	175 (96.2)	4.0 (1.1)
I believe using VPs would help me to improve my communication skills.	173 (95.1)	3.8 (1.1)
Overall, I think VPs would be a good asset to my educational process.	174 (95.6)	3.9 (1.0)

Abbreviations: VPs=virtual patients.
[a] Not all respondents answered all items.
[b] 5-point Likert scale on which 1=strongly disagree and 5=strongly agree.

users regarding the potential use of electronic-assisted learning and virtual patients.

All mean values were on the positive side of the Likert scales for pharmacy students who claimed they had no experience using virtual patient technology. The strongest expression of confidence in virtual patient technology use was in relation to items regarding positive beliefs in e-learning (56% agreed), and virtual patient technology being a good asset for learning and education. The most negative opinion was regarding professionals' interaction with patients, which was the only item on which there was a significant difference between male and female respondents ($p=0.037$): female respondents showed more confidence in the use of virtual patient technology to improve their communication skills. There were no significant differences in responses based on age, although ANOVA found differences in responses among universities for 2 items, professionals' interaction with patients and the overall value of virtual patients as a resource ($p<0.001$ and $p=0.001$, respectively). However, because of low representation per country, it was not possible to perform post-hoc testing.

Polish and Spanish pharmacy students had positive perceptions of virtual patient technology use, whereas confidence in this technology was more circumspect for the French and Dutch in particular, as well as for the Swiss and the Danes. Students from these last 4 countries disagreed that using virtual technology would help to improve their communication skills. The only strong significant correlation was between items 2c and 2d, belief in the ability of virtual technology use to improve communications skills and belief that virtual technology would be an asset to their educational process ($p<0.001$).

DISCUSSION

Simulation-based medical education has been used since the 1970s and has covered many different objectives, including student feedback on instructor training as well as skill acquisition and maintenance as an outcome measurement.[26] The first decade of the 21st century has seen many developments in computer-assisted instruction, ranging from applications on the World Wide Web[27] to dynamic interactions, provider and patient bidirectional communication, often described as virtual patients.[28,29]

Virtual patient technology in pharmacy education has been available at only a few institutions since the mid-2000s, with their usage in Europe being uncommon. The existence of somewhat sophisticated clinical cases, presented through computer programs and providing access to shared IT platforms, would suggest greater use of virtual patient technology. However, advanced dedicated-software solutions, designed to mimic real patient interactions as closely as possible in a virtual scenario, making use of 3-dimensional images and sound, still do not appear to be common in European pharmacy education today. It seems that most European universities have not invested in IT solutions for this purpose, despite contemporary society's dependence on computers for a vast array of activities, ranging from simple interpersonal communication to social networking. Although IT is widely accessible and actual virtual patient technology initiatives in healthcare education exist, its low implementation in pharmacy education within a European matrix of culturally and economically diverse countries is somehow intriguing.

To augment implementation, the development of virtual patient scenarios applicable to all health care professions and resource sharing among professions and institutions has been encouraged.[30] One example of cooperation in this area is the European eViP initiative (http://www.virtualpatients.eu/), which works with interactive computer simulation of real-life clinical scenarios for medical training, education, or assessment. This project (now closed), co-funded by the European Commission, was designed to be culturally adaptable and to address other healthcare professions. Although endorsing the importance of virtual patient technology as an educational tool for future pharmacists, there has been little or no transposition of eViP to European pharmacy education.

This deficit may be primarily related to the medical focus of the project but also indicates, to some extent, the need for pharmacy-related influence and involvement in advanced educational projects.

Despite the scarcity of virtual patient technology use in European pharmacy education, the undergraduates who reported using virtual patients were reasonably satisfied with their experience. The most unfortunate aspect was the lack of easy access to virtual patient technology, which suggests that the systems in use may not be simple computer software or Web-based applications, but rather may involve sophisticated electronic equipment associated with the production of realistic virtual scenarios. On the other hand, the use of virtual patient technology in conducting examination was considered less effective, suggesting that virtual technology may still be viewed by some as experimental and not reliable as an assessment tool.

Based on their responses, even if students believed that electronic patient simulation had a positive impact on learning, they were not as confident that knowledge and skills gained through use of virtual patient technology would be helpful/advantageous in a real-life situation. This is an interesting observation, as simulation is a well-established training method in medical science and even mandatory in professions such as aviation. Students expressed doubts as to the actual capacity of virtual patient technology to accurately portray real-life situations in a comprehensive way. Therefore, while suggesting that virtual patient technology offers an imperfect approach to reality, users of this resource discredit the potential training benefits or are unhappy with the degree of authenticity.

The vast majority of pharmacy graduate respondents who had not had experience with virtual patient technology believed it to be advantageous as a supplementary knowledge tool or in skill development, but, again, not necessarily as a method for assessing that expertise or skill. This disparity between the usefulness of virtual patient technology in learning and assessment denotes a lack of confidence in virtual patient applications as a sound method for establishing a course or examination grade. However, methods for using virtual patient programs as assessment tools in medical and nurse education may differ from those used in pharmacy.[31,32]

Computer-assisted learning, including virtual patient technology, may be considered a privileged means for developing important skills, such as interpersonal communication.[33] Virtual patient technology enables universal access to specific standardized clinical situations, allowing for repeated practice, even if the quality of the communication does not necessarily match that of a simulated patient in terms of emotional content.[34] In the non-virtual patient technology user group, women were more confident than men that virtual patients were beneficial to the development of their interactive skills, which might be related to women's societal role as caregivers and their perceived heightened sensitivity.[35] Likewise, students from different countries expressed doubts regarding the benefits of virtual patient technology, although the numbers from each country were low. French and Dutch undergraduates were the most skeptical, which prompted the examination of French and Dutch pharmacy education country profiles (PHARMINE project database http://www.pharmine.org/). The system in France is demanding, with a highly selective traditional examination at the end of the first year as well as the prompt introduction of professional experience in the form of a 6-week traineeship in community pharmacy in the second year. Meanwhile, in the Netherlands, pharmacy education is heavily directed toward the pharmaceutical industry. For example, 27% of the Dutch students' learning is in chemical sciences and only 3% in medical sciences during the first 4 years of their curriculum. These 2 countries illustrate 2 different bases that would account for a lower appreciation of virtual patient technology: either there is frequent contact with real patients or the program's focus is on drug discovery and development. Additionally, apart from a program's structure and goals, other hurdles, such as financial constraints, contribute to the weak implementation of an available technology. Future research using different information sources is needed to confirm and expand on the findings from this study.

Study limitations include a convenience sampling strategy, low rate of participation, and information bias. Although this study was exploratory by nature, there is no information on how congress participants might represent the actual student population at large, and any comparisons between users and non-users subsamples should be done with caution. On the other hand, the exact number of congress participants may have been greater than 304, primarily because of some unregistered Portuguese participants representing universities with limited implementation of virtual patient technology.

Although the survey preamble and individual questions included an introductory text outlining the definition of a virtual patient, not all respondents may have interpreted the concept in the same way, accounting for random variations in replies that are impossible to quantify. There were 3 countries (Latvia, Lithuania, and Sweden) in which participants might not have experienced virtual patient technology, considering that none of those students had reached the later stages of their degrees program (ie, fifth or sixth year). Additionally, there were only a few respondents from each country, which limits conclusions about national differences.

CONCLUSIONS

Virtual patient technology use in Europe is not as common in pharmacy education as in medicine and nursing education. Although individual universities may have developed or purchased virtual patient software, which in both cases implies heightened consumption of financial and other resources, a collective European initiative toward developing common pharmacy virtual patient scenarios would be a first step to implementing this valuable resource in pharmacy education. Such an initiative seems especially relevant given the specificities of pharmacists' work with patients, in particular to what concerns nonprescription drug counseling and medication therapy management.

ACKNOWLEDGEMENTS

The authors thank the EPSA executive board members, as well as Lisbon 2011 conference organizers and participants.

REFERENCES

1. Fanning R, Gaba D. Simulation-based learning as an educational tool. In: Stonemetz J, Ruskin K, eds. *Anesthesia Informatics*. New York: Springer; 2009.
2. Brazeau GA, Meyer SM, Belsey M, Bednarczyk E M, et al. *Future Pharmacy Graduates – Making More Opportunities Than We See*. White Paper for the American Association of Colleges of Pharmacy (AACP). Curricular Change Summit. March 2009.
3. Cook DA, Erwin PJ, Triola MM. Computerized virtual patients in health professions education: a systematic review and meta-analysis. *Acad Med*. 2010;85(10):1589-1602.
4. Huwendiek S, de Leng BA, et al. Towards a typology of virtual patients. *Med Teach*. 2009;31(8):743-748.
5. Andreatta PB, Maslowski E, et al. Virtual reality triage training provides a viable solution for disaster-preparedness. *Acad Emerg Med*. 2010;17(8):870-876.
6. Hurst HM, Marks-Maran D. Using a virtual patient activity to teach nurse prescribing. *Nurs Educ Pract*. 2011;11(3):192-198.
7. Radon K, Carvalho D, Calvo M J, Struempell S. Implementation of virtual patients in the training for occupational health in Latin America. *Int J Occup Environ Health*. 2011;17(1):63-70.
8. Orr KK. Integrating virtual patients into a self-care course. *Am J Pharm Educ*. 2007;71(2):Article 30.
9. Keele University. 'Virtual Patient' helps train pharmacist of the future. In: Forever Keele Issue 4. Keele: Keele University Alumni Office, 2009.
10. Fleming M, Olsen D, Stathes H, Boteler L, et al. Virtual reality skills training for health care professionals in alcohol screening and brief intervention. *J Am Board Fam Med*. 2009; 22(4):387-398.
11. Carbonaro M, King S, Taylor E, et al. Integration of e-learning technologies in an interprofessional health science course. *Med Teach*. 2008;30(1):25-33.
12. Cook DA, Triola MM. Virtual patients: a critical literature review and proposed next steps. *Med Educ*. 2009;43(4):303-311.
13. Stevens A, Hernandez J, Johnsen K, et al. The use of virtual patients to teach medical students history taking and communication skills. *Am J Surg*. 2006;191(6):806-811.
14. Huwendiek S, Reichert F, Bosse HM, et al. Design principles for virtual patients: a focus group study among students. *Med Educ*. 2009;43(6):580-588.
15. Gesundheit N, Brutlag P, Youngblood P, et al. The use of virtual patients to assess the clinical skills and reasoning of medical students: initial insights on student acceptance. *Med Teach*. 2009;31(8):739-742.
16. Botezatu M, Hult H, Fors UG. Virtual patient simulation: what do students make of it? a focus group study. *BMC Med Educ*. 2010;10:91.
17. Huang C. Virtual labs: e-learning for tomorrow. *PLoS Biol*. 2004;2(6):734-735.
18. Chaikoolvatana A, Goodyer L. Evaluation of a multimedia case-history simulation program for pharmacy students. *Am J Pharm Educ*. 2003;67(1):Article 16.
19. Hussein G, Kawahara N. Adaptive and longitudinal pharmaceutical care instruction using an interactive voice response/ text-to-speech system. *Am J Pharm Educ*. 2006;70(2):Article 37.
20. Benedict N. Virtual patients and problem-based learning in advanced therapeutics. *Am J Pharm Educ*. 2010;74(8):Article 143.
21. Ruderich F, Bauch M, Haag M, et al. CAMPUS - a flexible, interactive system for web-based, problem-based learning in health care. *Stud Health Technol Inform*. 2004;107(Pt 2):921-925.
22. Zary N, Johnson G, Boberg J, Fors UG. Development, implementation and pilot evaluation of a web-based virtual patient case simulation environment–Web-SP. *BMC Med Educ*. 2006;21:6:10.
23. Smothers V, Ellaway R, Balasubramaniam C. eViP: sharing virtual patients across Europe. *AMIA Annu Symp Proc*. 2008;2008 (Nov. 6);1140.
24. Zary N, Johnson G, Boberg J, Fors U. Development, implementation and pilot evaluation of a web-based virtual patient case simulation environment – web-SP. *BMC Med Educ*. 2006;6:10.
25. Morgan P, Cleave-Hogg D, Desousa S, Lam-Mcculloch J. Applying theory to practice in undergraduate education using high fidelity simulation. *Med Teach*. 2006;28(1):e10-e15.
26. McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003-2009. *Med Educ*. 2010;44(1):50-63.
27. Hammoud MM, Barclay ML, Wiecha JM, et al. Complementary, alternative, and integrative medicine. Special feature: Applications of the World Wide Web. *Acad Med*. 2002;77(9):925-929.
28. Ellaway R, Poulton T, Smothers V, Greene P. Virtual patients come of age. *Med Teach*. 2009;31(8):683-684.
29. Saleh N. The value of virtual patients in medical education. *Ann Behav Sci Med Educ*. 2010;16(2):29-31.
30. Ellaway R, Poulton T, Fors U, McGee JB, Albright S. Building a virtual patient commons. *Med Teach*. 2008;30(2):170-174.
31. Round J, Conradi E, Poulton T. Improving assessment with virtual patients. *Med Teach*. 2009;31(8):759-763.
32. Forsberg E, Georg C, Ziegert K, Fors U. Virtual patients for assessment of clinical reasoning in nursing: a pilot study. *Nurse Educ Today*. 2010: In press, corrected proof. http://www.sciencedirect.com/science/article/pii/S0260691710002418. Accessed May 5, 2012.
33. Bearman M, Cesnik B. Comparing student attitudes to different models of the same virtual patient. *Stud Health Technol Inform*. 2001;84(Pt 2):1004-1008.
34. Deladisma AM, Cohen M, Stevens A, et al. Do medical students respond empathetically to a virtual patient? *Am J Surg*. 2007;193(6): 756-760.
35. Dwyer JW, Coward RT. A multivariate comparison of the involvement of adult sons versus daughters in the care of impaired parents. *J Gerontol*. 1991;46(5):S259-269.